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Ronald K. Hanson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Department of Mechanical Engineering
Stanford University.

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This award enabled purchase of three instrumentation systems used ~~in AFOSR~~ sponsored research on digital flowfield imaging of reacting flows and plasmas. System I is a high-resolution, high dynamic range, solid-state camera system; System II consists of elements for 3d flowfield visualization; and System III is an image processing system. System I (funded in FY 84) was completed in the first year and is now in use in fluorescence-based flowfield imaging experiments. System II (funded in Fy 85) is not yet fully assembled and will be completed as part of our ongoing ~~AFOSR~~ research. System III has recently been completed ((funding was distributed between FY 84 and FY 85) and is in the final phase of being incorporated into the Laboratory computer networking system.

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Final Report

URIP FY 84/85

"Advanced Flow Visualization and Image Processing Instrumentation"

AFOSR-84-0194

P.I.: Professor Ronald K. Hanson
Department of Mechanical Engineering

July 1986

Final Report

Summary

This award enabled purchase of three instrumentation systems used in AFOSR-sponsored research on digital flowfield imaging of reacting flows and plasmas. System I is a high-resolution, high dynamic range, solid-state camera system; System II consists of elements for 3-d flowfield visualization; and System III is an image processing system. System I (funded in FY 84) was completed in the first year and is now in use in fluorescence-based flowfield imaging experiments. System II (funded in FY 85) is not yet fully assembled and will be completed as part of our on-going AFOSR research. System III has recently been completed (funding was distributed between FY 84 and FY 85) and is in the final phase of being incorporated into the Laboratory computer networking system.

System Descriptions

Brief descriptions of the equipment systems acquired follow below. The integration of system I and III into one overall image acquisition and processing facility is shown in Fig. 1.

a. System I: High Resolution, High Dynamic Range, Camera System

Fabricated System: Includes an image intensifier, high resolution Thomson CCD array (384 x 576), buffered interfaces, display processors, and miscellaneous computer components and software.

b. System II: Three-Dimensional Data Recording System

Fabricated System: Includes custom fast-gated intensifiers and matched power supplies, UV laser source, special optics for UV beam handling, high-speed electronics, microcomputer hardware/software.

c. System III: Real-Time Imaging Processing System

Fabricated System: Includes 32-bit super-mini computer (VAX 11/750 from DEC), peripheral processing and display hardware and software, digital and analog data transmission interfaces, and networking components.

Description of Research

The High Resolution, High Dynamic Range Camera System was successfully assembled and has been tested in terms of its spatial resolution and dynamic range. An illustration of system performance for this 384 x 576 pixel CCD system, relative to our current 128 x 128 photodiode array camera system, is shown in Fig. 2. In addition to the apparent improvement in spatial resolution, the new system also exhibits a larger dynamic range, by about a factor of fifty. (We define the dynamic range as the ratio of the maximum allowed signal, which just saturates the detector, to the minimum resolvable (i.e., S/N = 1) signal.) The camera is now in use in fluorescence imaging research, and two papers have been written based on the results obtained. An example result for the instantaneous concentration field produced by a jet of biacetyl into nitrogen is shown in Fig. 3.

The Three-Dimensional Data Recording System is not yet fully assembled and hence has not yet been tested or used in research. We expect the system to be complete by the end of the calendar year.

The Real-Time Image-Processing System is intended for use in digital processing of flowfield image data. As an example, single-frame 2-d image data will be processed to improve signal-to-noise ratios, to enhance specific aspects of images, such as edges, and to evaluate various correlations (such as scale-sizes, mean intervals, characteristic shapes, etc.) in the data. At present we are using the system (in conjunction with prerecorded multiple planes of 2-d fluorescence data) to generate 3-d data displays and to investigate concepts for processing and display of 3-d

data. We anticipate the overall System will be fully operational and debugged by the end of the calendar year.

System Location

These systems are located in the High Temperature Gasdynamics Laboratory, building 570 on the Stanford campus.

System Cost

AFOSR Award:	$300,000
Univ. Cost-Sharing:	$ 24,800
Total Systems Costs:	$324,800

Distribution of Costs between Systems (approx.):

System I:	$125,000
System II:	$ 75,000
System III:	$124,800
Total Expenditures:	$324,800

Additional costs of installation (labor and components) and peripheral items have been supported by relevant research grants and contracts.

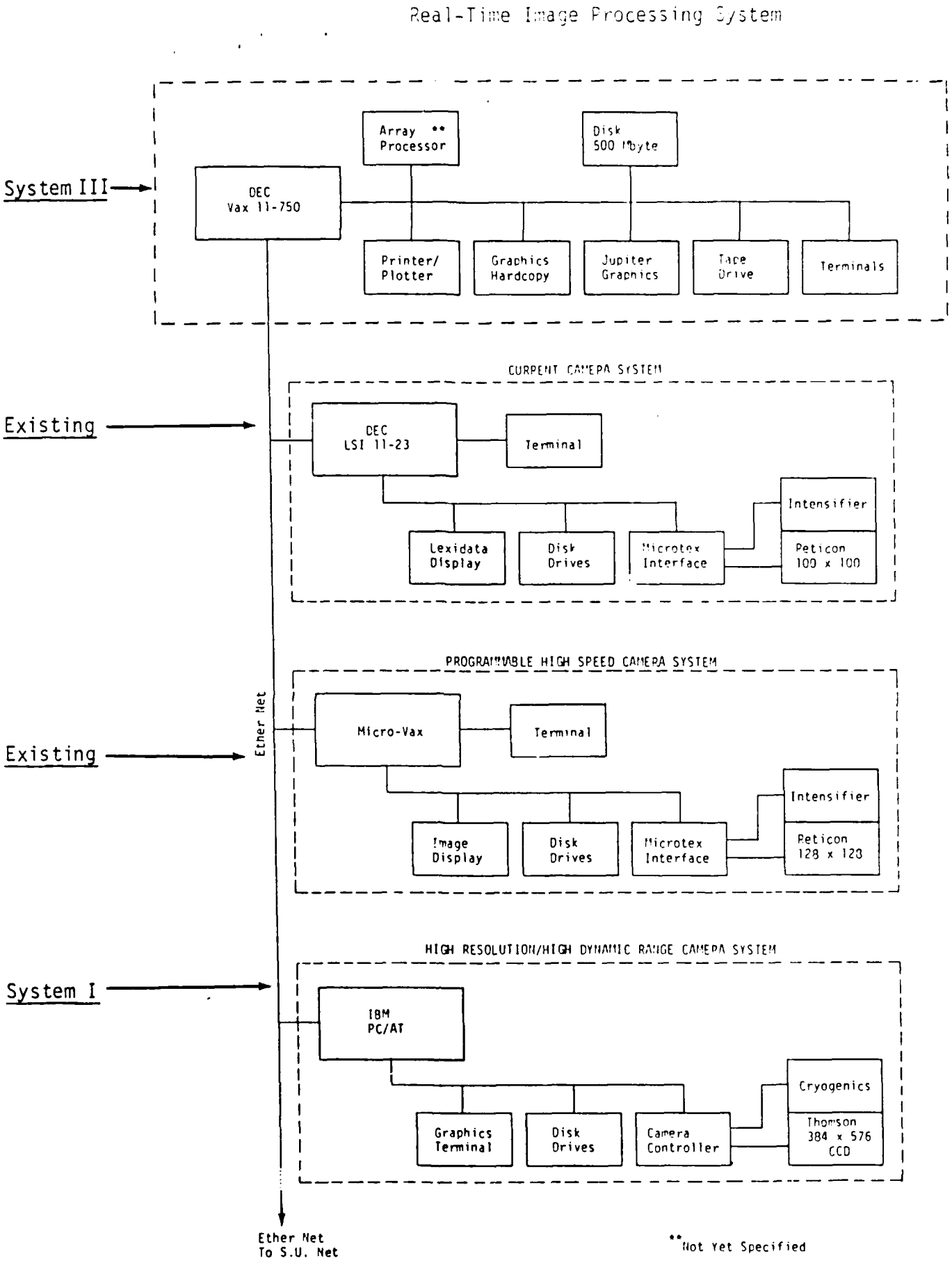
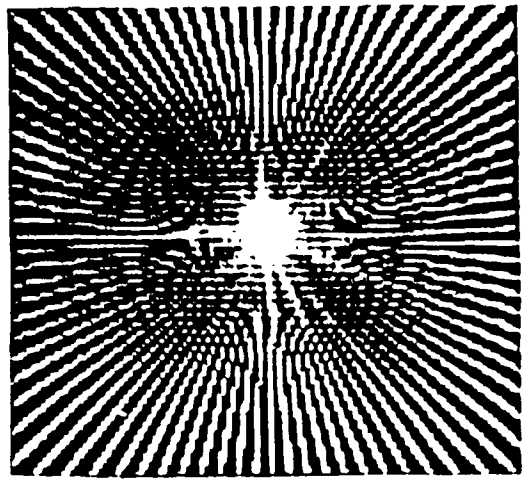


Fig. 1. Schematic diagram of HTGL image acquisition and processing facility.



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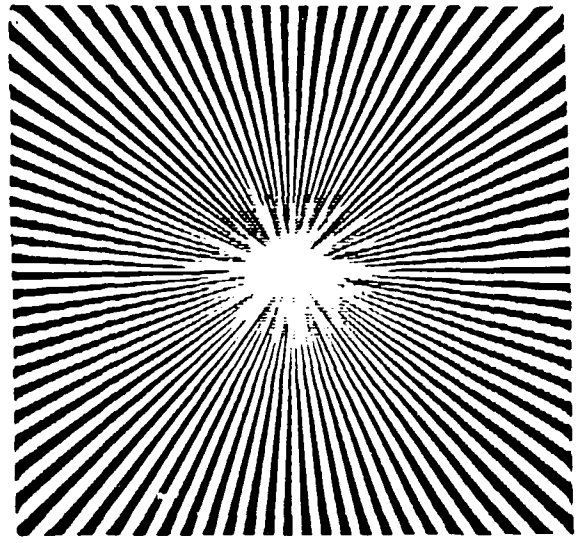

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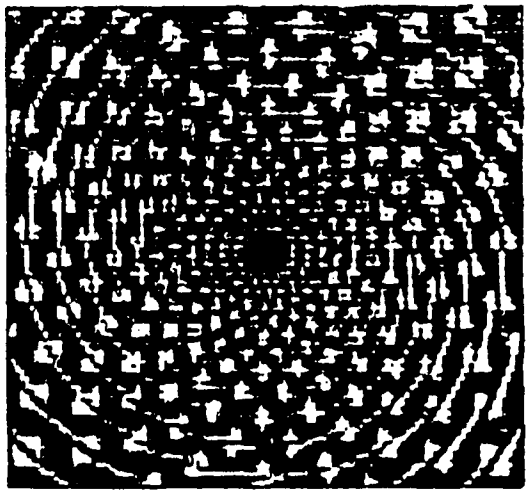

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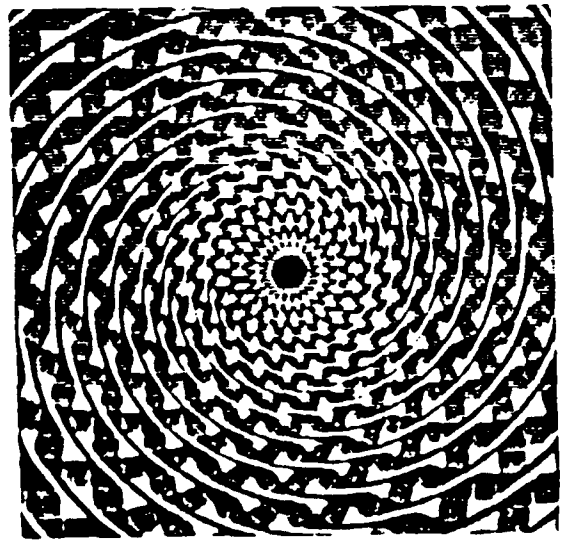

384 x 576

Fig. 2. Illustration of additional observable details resolvable with higher resolution solid-state camera. The two cameras have 128 x 128 and 384 x 576 pixels respectively.

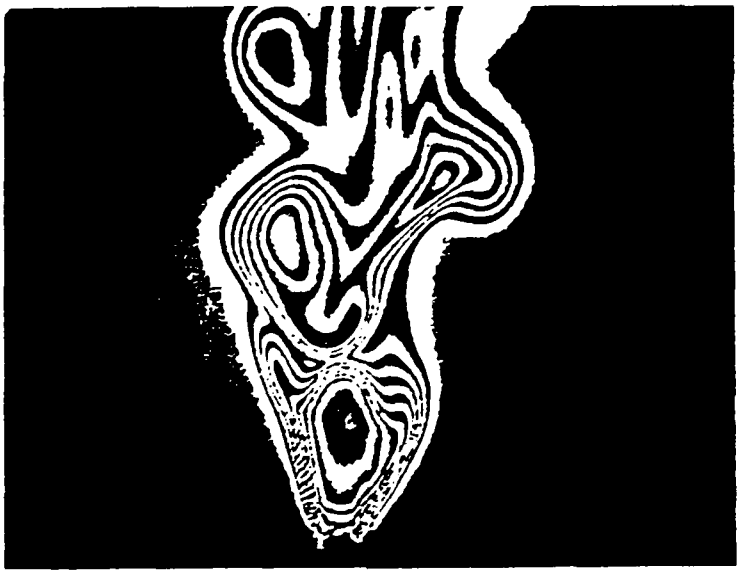

Fig. 3. PLIF image of unsteady jet obtained with high-resolution (384 x 576 pixel), high dynamic range CCD camera.